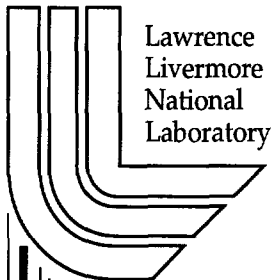


Secure, Transportable, Autonomous Reactor (Star) Concept

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Secure, Transportable, Autonomous Reactor (STAR) Concept

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The Secure, Transportable, Autonomous Reactor (STAR), is a concept for a small, highly proliferation resistant, sealed-core nuclear power system with unique design features that make it appropriate for a variety of applications.

STAR features include:

- Long lifetime sealed core installed at construction
- 10 to 30 year core life, depending on design and size
- No capability for on-site refueling, no user access to the fuel, no need for user to have fuel cycle technology
- Reactor transported intact to the user site
- Reactor core is replaced by vendor at end of life, spent fuel returns intact to supplier
- Useable in remote areas for local power
- Modular design for factory production to minimize cost
- Simple operation with reliance on autonomous control and remote monitoring
- Robust, simple design with inherent safety features, high reliability and reduced maintenance

These features permit STAR to address a variety of potential applications, including:

- Deployment in developing countries with limited infrastructure
- Remote/isolated location deployment (islands, oil fields, military installations, etc.)
- Central generation on small electric grids
- Multi-unit central station use or distributed generation on large electric grids
- Alternative energy products (process heat, space heat, fresh water, hydrogen, etc.) in addition to electricity

The current STAR concept builds on earlier work^{1, 2, 3} that investigated the features required for implementation of such a system and evaluated a variety of reactor types. These prior evaluations considered water cooled, gas cooled, liquid metal cooled and molten salt reactors, both thermal and fast spectrum in a variety of sizes. To meet the long core life, transportability, simplicity and safety objectives, a small liquid metal cooled fast spectrum reactor has been chosen as the most promising. A fast spectrum reactor can achieve very long core life with a balance of fissile and fertile material. Use of a fast neutron spectrum could also allow for effective consumption of excess weapon useable fissile material, if this application is needed. The small active core, modest energy density and the thermal properties of liquid metal coolant facilitate designing inherent and passive safety features into the system to mitigate all credible conditions. Such small nuclear systems can be kept simple and virtually autonomous with minimal maintenance. The user primarily operates the non-nuclear portion of the plant and just monitors the nuclear system. With simple operation, minimal maintenance, inherent safety and no refueling, the operating staff and costs are minimized. Factory mass production can reduce capital cost. The user does not need nuclear fuel fabrication or spent fuel management

infrastructure. System economics may be controlled by the up front fuel costs, but modest fuel cost is a strong point for nuclear energy economics.

STAR design covers a range of output and lifetime, traded against transportation weight. The nominal design is sized in the range of 50 to 150 Mwe, with larger demand accommodated through installation of multiple units. More compact designs as small as 10 Mwe are possible for special applications. The larger size could be delivered by ship or barge, small systems could be transported by rail or heavy surface transport.

Proliferation resistance is enhanced by several features of the STAR concept. The reactor supplier (from an advanced nuclear technology nation – US, France, Russia, etc.) would be responsible to the international community for proliferation safeguards in the entire fuel cycle, rather than the user. Implementing this concept will require development of a mechanism for “Safeguards Transparency Certification” from an international body such as a ‘Nuclear Suppliers Organization’. This relieves the reactor user of much of the burden of international scrutiny. The user would not require extensive infrastructure and nuclear expertise, and would not have access to the fuel or fuel cycle facilities. Material diversion would require diversion and disassembly of the entire reactor and would be time consuming and easily detected. Clandestine material production would be precluded by lack of user access to the core. This safeguards concept is similar to the safety certification of advanced jet airliners by a limited number of high tech suppliers, that are then used by airlines all over the world with pilots that only need to know how to fly them, not build them. Acceptance of this safeguards approach by the international community would further reduce operating cost to the user, with the supplier picking up much of the responsibility.

STAR is fully consistent with the “Joint Study on Enhancing the Proliferation Resistance of Nuclear Technologies” where U.S. DOE and Russian Minatom agreed that small, transportable, sealed-core reactors, are a technology with potential to reduce proliferation risk in the future

A survey⁴ completed by the International Atomic Energy Agency (IAEA) indicated the need for such systems and that by the year 2015, developing countries are expected to need 70-80 small and medium sized reactor systems. In the U.S., nuclear operating companies have expressed interest in several types of small modular reactors that can be built with moderate investment risk compared to large reactors, and deployed in multiple units to meet demand. Currently, other countries are developing small reactors for this potential commercial market, but these efforts tend to focus on the development of the reactor without integrated considerations of the overall fuel cycle, proliferation or waste issues. It is important for the next generation of reactors to meet to U.S. global non-proliferation objectives, and for the U.S. to regain its historical technology leadership in nuclear energy.

The development of STAR systems can greatly enhance the safety, safeguards and international transparency features of nuclear plants. But successful fabrication of STAR systems requires the development of very long-lived cores; innovations in fuel, cladding, and structural materials; advances in control and reactivity-compensating materials; and development of new techniques and models for the prediction of materials behavior and design performance. STAR development necessitates not only an integrated set of technical R&D activities, but also international participation. A STAR development project is envisioned to consist of three phases leading to a preliminary system design in five years. In the first phase (lasting approximately 18 months), detailed system requirements will be developed; feasibility issues will be identified and

addressed; and a technology down-selection to one or two candidate reactor systems will be performed. In the second phase (also lasting approximately 18 months), the technology research and development program needed to perform a final conceptual design will be identified and implemented. In phase 3 (lasting approximately 2 years), the conceptual design will be completed. At the end of the five-year program, all the necessary data will have been generated for initiation of detailed design and development of a prototype.

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